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ABSTRACT

Based on the conviction that research findings on effective design of educational television programs may have useful lessons for designers of educational computing software, this paper reviews research on children's educational television and discusses ways in which the findings can be applied. The paper divides the research findings into the following sections: (1) children's attention and comprehension, (2) the settings for viewing and computing, (3) trends during viewing/computing sessions, (4) visual design attributes, and (5) auditory design attributes. A five-page bibliography concludes the paper. (HOD)

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Television's Lessons for Educational Computing

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Computers are beginning to take the place of television as the communications medium expected to have most impact on children's education. However, the history of educational television suggests that considerable effort will have to be devoted to educational software design for the computer's potential to be realized. Compared to educational computing, educational television has been studied a great deal more. Since computers and television share some visual and auditory display characteristics, research findings on effective design of educational television programs may have useful lessons for designers of educational computing programs.

In this article I discuss research on children's educational television and try to show how it could be applied. The age range on which the largest amount of research has been done is from three to twelve years. In concentrate my discussion on this age range. When I refer to younger children in the paper I mean children at the bottom end of the range (ages 3 to 5 years). When I refer to older children, I mean children at the top end of the range (ages 7 years and on). The paper divides research findings into the following sections: children's attention and comprehension; the settings for viewing and computing; trends during viewing/computing sessions; visual design attributes; and auditory design attributes.

A. Attention and Comprehension

Ideally educational computer programs should have enough appeal for children to want to use them and yet enough educational content for children to learn something from them. This raises the question of whether it is possible to meet both goals. Television studies seem to say that it is. For

example, Anderson has shown that children's attention and comprehension are related (Anderson, Lorch, Field, & Sanders, 1981a). Children pay more attention to television program segments they understand than those they do not understand.

However, the relationship is not entirely straightforward. Older children need to pay less attention to understand the same programs than do younger children (Hughes & Krull, 1983; Anderson & Lorch, 1982). This may be in part because older children have better comprehension in general. It may also be because older children are more efficient viewers of television (more on that below).

One implication of these findings to computing is that designers of educational programs may have to plan for both educational value and attention-gaining devices if programs are to be effective. This would be the case when computer programs are used by children at home. They are unlikely to want to learn from computing programs they find boring and incomprehensible when they have alternatives such as watching television or playing with friends.

Another implication is that computer programs may only fit certain age groups of children or children with specific levels of experience. Computer programs may have to be designed either for specific groups of children or to offer children a choice of skill levels. Both the setting in which programs are used and the abilities of children are discussed further below.

B. The Viewing Situation

Research has shown that alternatives to viewing affect the amount of

attention children pay to the TV screen. The more compelling the alternatives, the lower the overall level of attention (Anderson, Lorch, Smith, Bradford, & Levin, 1981b; Krull, 1982; Epstein, 1977). Children who have no alternative to viewing tend to pay high attention to the TV set.

An implication of this finding to computing is that children in school settings may concentrate on computer tasks even though they find them dull. Children at home may stop using such programs because they have more attractive alternatives such as watching television. This may mean that programs designed for the home may have to be higher in entertainment value than those designed for school systems.

Two other aspects of the TV viewing setting that affect children's overall attention are that children often leave the room during viewing periods (Krull, 1982; Bechtel, Achelpohl, & Akers, 1972) and children interact in front of the set (for example, Lasker, 1974) making attention levels unstable.

How similar these attention patterns with TV are to the interaction of children with computers has not been studied extensively. Some of the information we have available about children's computing indicates that children do interact while using computers (Geoffrion & Geoffrion, 1983). If studies show the typical level of interaction among several simultaneous users to be high, designers could optimize programs by planning for it. For example, they could design instructional applications that allow for the separate entry of two people's responses, or programs that plan for different roles for children. One child could handle some logical tasks, such as keyboarding; and other children could handle other tasks, such as reading

from a book containing relevant information. In fact such interaction may be planned for implicitly by educational computer programs that are more difficult to get running and operate than the educational skills supposedly taught. Spinnaker Software, for example, suggests that parents help their children learn from programs. However, the parents' role is not formally designed into Spinnaker's computer programs.

The number of alternatives to viewing affects not only the overall level of attention, but also produces trends in attention. Compelling alternatives to TV viewing produce a steadily decreasing level of attention to the screen during a viewing period (Husson & Krull, 1983; Anderson, et al., 1981b). When applied to computers, this may mean that designers should plan either periodically to rekindle the attention of distracted home users, or to allow programs to be used in short sections. For programs that involve progressive, sequential learning, planning for usage in short segments may also mean that children should be able to get to the specific segment where they stopped during preceding sessions.

Children's attention to the TV screen is not entirely unpredictable. In the next section I discuss two related points discuss -- attention "spans" and attention "rhythms."

1. Attention Flexibility and Inertia. Sometimes attention span is thought of as a discrete time period during which someone will pay constant attention. While this view may describe attention to static tasks like working with workbooks, television research has shown a pattern of attention that is more oscillatory. For television, and perhaps for computing, it seems more relevant to speak of attention flexibility versus attention "inertia" than to

span of discrete "spans." For example, compared to younger children, older children change more quickly from attention to inattention during programs (Krull & Husson, 1979, 1980; Anderson & Lorch, 1982. Older children also are more sensitive to rhythms in TV program attributes (Krull, Husson, & Paulson, 1978; Huston, Wright, Wartella, Rice, Watkins, Campbell, & Potts, 1981). As a result, older children are likely to sample the screen periodically to see if anything of interest is being shown (Krull & Husson, 1979; Anderson & Lorch, 1982).

Applying the findings given above, one could argue that computer programs for younger children should be pedestrian in pacing. For example, such programs should contain segments with clear beginnings and endings, and an obvious progression from one to the other. Young children's inflexibility in attention might lead them to be confused when they see more complicated segments. Computer programs for older children might plan for their greater flexiblity in attention.

A related point is that the placement of important information may need to be different for younger than older children. Since younger children may need some time to orient themselves to the information on a computer screen and may not be paying attention to the proper parts of screens, important information could be presented after a short orientation period. For older children, this orientation period could be shorter. Determination of the actual length of such periods will require research beyond that presently available.

2. Attention Inertia and the New Viewer. When children of all ages watch a television program for the first time, they tend to pay high attention

(Krull & Husson, nd). This may be because even older new viewers may have trouble determining which parts of programs are central and which incidental (Collins, 1979). As a result they tend to watch everything as they try to understand how a program is organized.

Young children may react negatively to programs they don't understand (Anderson, et al., 1981a). They may have initial difficulty with unusual programs even when they are simple in structure. A few studies have shown that children watching television design their own method of controlling the rate of information they receive (Flagg, 1978; Robinson, 1969).

Taken together, these findings suggest that attention discrimination takes experience to develop. For computer program designers this means that they should plan for a learning period. Children may initially have considerable difficulty with a computer program. After some practice, they may become bored with material they initially found challenging, merely because of their unfamiliarity with it.

Research in computing has shown that this pattern of learning from experience appears with adult users of computers and that advance planning for a learning period is useful (references to computer stuff). Programs designed for levels of learning are said to be "layered." An example of layering is a program's offering a user information describing how the program is to be used at different levels of detail. It is likely that children's educational computer programs could profit equally well from layering.

C. Program Structure and Attention Trends

Research on television shows that, in spite of popular criticism that

children are glued to TV sets, children's attention during a viewing period actually fluctuates substantially (Krull & Husson, 1979; 1980). Children's levels of attention are affected both by overall program structure and by specific programs attributes. In this section I describe structural factors in programs. The effects of specific program attributes will be discussed in the following major section.

During an hour-long TV program children's reactions to program attributes are non-stationary (Husson & Krull, 1983). That is, children do not react the same way to program attributes at the beginning of the hour as at the end. For example, children may become tired simply from watching for a long period of time. They may stop paying attention to program segments that require a good deal of effort.

To reduce satiation effects, television programs such as "Sesame Street" are divided into segments, or bits. However, research indicates that long bits often produce eventual declines in attention (Krull & Husson, 1979; Anderson & Levin, 1976). To solve this problem, "Sesame Street" is produced as a mixture of longer and shorter segments (Lesser, 1974). In that way children's attention may be rekindled by groups of short segments after it has been taxed by long segments.

For computer programming these findings may mean that long educational segments also reduce children's interest. A mixture of comparatively taxing and short entertaining educational segments make be effective with computer programs as well. However, research probably needs to be done on the optimum lengths of educational computing segments for different groups of children and kinds of educational material.

Some research indicates how children cope with program segmentation. If segments are short, younger children's attention spills over from one to the next (Krull & Husson, 1979; Anderson & Lorch, 1982). These children also have difficulty discriminating between scene changes (different scenes that appear in a single story, for example) and segment changes; and connecting scenes or segments to one another (Collins, 1979; Collins, Wellman, Keniston, & Westby, 1978). For example, sometimes children could still be trying to understand the last segment when they are shown the next (Calvert & Watkins, 1979). This pattern may appear because children have trouble separating central from incidental content (Collins, 1979).

An implication for computing is that, when the audience consists of younger children (3 to 5 years of age), there should be either few or clearly demarcated divisions between program segments. For example, television programs announce program demarcations in part by dramatic visual changes like camera cuts to substantially different looking material. In computer programs one can either make changes in individual screens of information, or change to information placed in an entirely different format. To young children, a program's maintaining a largely unchanging visual field may indicate that the content is also part of a whole (a segment or bit). Dramatic changes from one screen layout pattern to another is likely to raise expectations in young children that there has been a change to a new segment. Designers of computer programs who use an inconsistent pattern of changing from one segment to another (sometimes through small changes, other times through dramatic ones) may confuse young children.

Another technique that seems to help both older and younger television viewers find segment demarcations is what Anderson calls "closing music."

For example, "Sesame Street" often accompanies the end of program segments with bright music. The music has been found to raise children's attention at the end of long program segments (Lorch, Anderson, & Levin, 1979). Computer programs could also use musical snippets and sound effects to point out segment changes, especially to children who are not looking at the CRT screen.

TV studies indicate that older children (7 years of age and on) attend when they expect several short exciting segments (Krull & Husson, 1980), and are better able than young children to make logical connections between segments (Collins, et al., 1978). In other words, older children have more elaborate expectations about overall program structure and more developed understanding of how programs are assembled.

Computer designers can apply this information by developing more complex programs for older children. Older children could be expected, after some practice, to have a better sense of the overall structure of a computer program. They may be able to make the logical connection between several conceptually related, but differently laid out screen images. However, computer programmers should probably be careful to keep programs for older children simple since even adults appear to become rapidly confused when interacting with computers (Al-Awar, Chapanis, & Ford, 1981; Carroll, 1983).

D. Attention and Program Attributes

Researchers have searched for effects of many visual TV program attributes. Among them are visual complexity and visual change. I will discuss the most primitive levels of visual activity first and then progress upwards in levels of abstraction. In other words, I start with the simple amounts of visual change and then progress towards things that can produce visual change (eg. children running around on a television screen).

1. Visual Change and Visual Complexity. In general, visual complexity is correlated with TV viewers' attention, but is more likely to maintain than elicit attention (Alwitt, Anderson, Lorch, & Levin, 1980). That is, visual complexity will keep someone looking at the screen rather than causing someone to look if he/she is not already doing so.

Visual complexity appears to have comparatively less effect on younger than on older children (Krull, 1982). In fact, young children stop scanning and look at just one part of the screen when they are provided with too much visual change (Flagg, 1978). Even after much experience with a specific television series, younger children never seem to be particularly discriminating about visuals (Krull, Hughes, & Husson, 1983).

By comparison, older children are more discriminating about visuals in general (Krull & Husson, 1979, 1980; Lasker, 1974). For example, they react more to changes from one camera shot of a TV scene to another. Older children also pay more attention to the TV screen during periods of rapid changes of scene (Krull & Husson, 1979), particularly after considerable experience watching a specific TV series (Krull & Husson, 1980, nd).

Effects of visual complexity on comprehension appear to be mixed. Younger children sometimes seem to have difficulty integrating complex visuals with the content of TV programs. For example, TV shot changes may aid young children's auditory recall, but seems to reduce their ability to place story events into their proper sequences (Hughes & Krull, 1983). Set changes, on the other hand, seem to reduce children's recall of verbal material but increase ability to sequence story events (Hughes & Krull, 1983).

Older children appear to appreciate complex visuals by themselves and to integrate their meaning with that of program content. For example, older children may better understand how visuals tell a story (Collins, et al., 1978) and seem able to anticipate set changes after experience watching a program with a consistent format (Krull & Husson, 1979, 1980; Krull, Husson & Paulson, 1978).

An implication of these findings for computing is that flashy visual by themselves may not add to the educational value of programs for young children. Children could concentrate on visuals and not learn what programs intend to teach; or, they could have so much difficulty understanding visuals that they become frustrated with using programs at all. It seems, then, that educational computer programs for young children should be visually simple rather than complex; and the relationship of visuals to educational themes should be straightforward.

Older children may better appreciate complex visual materials and that could maintain their interest in computer programs they might otherwise find dull. They also may be better able to relate complex visuals to educational themes. In addition, older children may understand a few implicit

relationships between visuals and educational themes. More on that in the next section.

2. Central and Incidental Visuals. Studies of children's abilities to pick out the central from the incidental material in television programs indicates this ability improves with age. Three to five-year-olds are poor at this task; 7-10-year-olds are considerably better (Collins, et al., 1978). All children perform more poorly when asked to integrate television story segments separated by long sections of incidental material.

The implication for computing is that younger target audiences will tolerate less extraneous material. If colorful or quick-moving graphics are included in a program to make it seem more exciting, they should have an integral function rather than just being tacked on.

Older children may be able to handle a small amount of extraneous material and still understand how a program functions; but even their limit is likely to be low. For example, even older children take some time to learn the production style of specific television series and TV series make low demands on children compared to many computer programs. Some computer programs are not tolerant of user errors. Adding extraneous material to such programs may confuse children, raise the number of errors they make, and increase how long it takes them to operate programs. Support for this view comes from studies that show adult computer users become confused with even apparently simple programs (Al-Awar, et al., 1981; Carroll, 1983).

3. Visual Change versus Visual Complexity. Visual displays can be complex in two different ways. One is for individual images to be complex. A computer user then has to sort through the information in each image.

Another is for individual images to be comparatively simple, but for there to be many of them. The computer user then collects information by sorting through the sequence of images.

Both systems have their problems (Krull, 1984), particularly for computer users who must look at images as well as negotiating among images. However, television research has information about the issue. Young children seem able to handle, and even be interested in sequences of images, each differing in a small way. Examples of this kind of change are visual sequences showing children running or shot changes between two people talking in a room (Alwitt, et al., 1980). In both cases the subjects of camera shots are largely the same from shot to shot.

More disturbing to young children is a complete visual change from one image to the next. An example of this on television is a camera cut between two different locations and different actors. Children have difficulty determining if this indicates a continuation of a preceding story or indicates a new story's beginning.

Applying this to computing, one could argue that visual change between panels of computer information should attempt to maintain some constant material to provide a context for young children. For example, rather than showing young children a sequence of panels, each of which has a different format and content, it may be better to show them panels with similar formats, but some clearly delineated changes. An example of such a design philosophy is the pop-up menus of the Apple McIntosh and similar computer systems. For older children the amount of visual a change between panels of information could be somewhat larger, but computing research indicates that

even here the amount of visual change that can be shown is limited (Al-Awar, et al., 1981; Carroll, 1983; Krull, 1984).

Neither younger nor older children should be saddled with learning complex systems of commands for moving between screen images. This should be either under computer control or should consist of some form of simple iconic system of commands with screen prompts. The Apple trash-can symbol is an example of such a system.

4. Sources of Visual Change and Complexity. In "Sesame Street" studies, Anderson found that children were attracted to images of women, muppets and children, and not to those of men (Anderson & Levin, 1976; Lorch & Anderson, 1978). Anderson theorizes this may be due to the attractive characters' being more active by moving more or doing things of greater interest to children. If that is the case, animated computer characters could easily be made active. TV programs also could be used as sources of information about character actions of interest to children.

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Anderson also found that animals in unplotted visual sequences draw little attention, although many commercial television programs showing animals in plotted action draw considerable attention. It seems important, then, for animated characters to be integral computer programs, rather than just being visual window-dressing.

A different issue relating to the source of visual change is the effectiveness of graphic devices. Studies of "Sesame Street" and "The Electric Company" have shown that a variety of graphics techniques are effective in directing children's attention to specific points on the TV

screen: speech balloons, motion and color changes in alphanumeric characters, and the like. In general these devices enhance understanding when they complement the educational theme; they reduce understanding when they used purely as entertainment. The implication for computing is that, again, graphics devices should point to educationally important parts of CRT screens.

D. Auditory Design Attributes

Although the menu of auditory computer program attributes tends to be limited by comparison to those of television, there are, nevertheless, sufficient similarities between the two media for research on TV audio to be relevant.

1. Audio Surface Qualities. Audio brightness (high pitched, quickly fluctuating, and loud sounds) seem to elicit children' looking at the television screen (Huston, et al., 1981; Krull, 1982). Constant, low pitched sounds, on the other hand, seem to depress attention (Alwitt, et al., 1980). It seems surface qualities of the TV sound track are important. Furthermore, both younger and older children seem to monitor program audio to tell them when something visually interesting is likely to appear on the screen (Anderson, et al., 1981a; Friedlander, Wetstone, & Scott, 1974; Krull & Husson, 1979).

These findings imply that computer designers can use sound effects to maintain children's interest. Since children seem to be interested in the surface quality of sound effects, the computer's limited capacity to provide voice reproduction and high quality music may not be a major impediment. However, there still should be some specific relationship between sound effects and computer visuals. The relationship can take at least two forms:

effects and computer visuals. The relationship can take at least two forms: between audio and a concrete referent on the screen; and between audio and its source.

2. Auditory Concreteness. Findings about the relationship between a sound and its referent show that an auditory cue to a concrete visual program attribute raises attention (Krull & Husson, 1979; Husson & Hughes, 1981; Anderson & Lorch, 1982). In general, children have difficulty understanding relationships abstractly presented (Ginsburg & Opper, 1969; Hildyard, 1979; Piaget, 1969; Anderson, et al., 1981a) and sounds without concrete referent often are abstract. For example, children stop watching when they don't understand what actors are talking about (Anderson, et al., 1981a). This kind of concreteness is particularly important to younger children (Krull & Husson, 1979).

A computing application is that programs should use sound effects to draw attention to educationally important points on screens. For example, a sound effect could accompany a visual effect such as color highlighting or flashing letters. The sound effect, if consistently used, could draw attention to the screen and flashing letters would indicate where on the screen to look. A similar application would be to use a sound effect to accompany movement on the screen. The sound and the movement then would be mutually reinforcing.

A third application would be to have sound signal when some process has begun or ended. In an earlier section I indicated that even young children have learned that "Sesame Street" uses closing music to indicate the end of program segments. A similar technique could be used to tell children when

they have successfully completed a task.

3. Visual Presence of Sound Sources. The second kind of relationship between audio and visuals involves that between the source of sounds and visuals. A typical example on television is a character speaking and simultaneously being shown on the TV screen. This factor does appear to influence children's attention. For example, in general, as the number of people speaking rises, so does attention (Krull & Husson, 1979, 1980). However, if many speakers are off-screen that depresses attention (Alwitt, et al., 1980; Husson & Hughes, 1981; Huston, et al., 1981). It seems to be better that those speaking appear on screen.

The implication of these findings for computing is that children may have difficulty understanding disembodied sound effects. If programs offer animated characters and other anthropomorphic forms, it seems best to tie sounds to them directly. Use their sound when they appear on screen; don't use it when they don't appear on screen.

In summary, I have discussed a few aspects of carry-over from educational television to educational computing. I have been able to discuss only a few topics and many remains untouched. "Sesame Street" and "The Electric Company" were produced by using information about learning from media other than television. A considerable amount of additional research was required to tune those cross-media applications. A similar effort probably will be required fully to exploit the suggestions I have made in this paper.

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